The objective of this viability study is to assess the potential of near infrared spectroscopy (VIS +NIRS) technology combined with multivariate analysis for characterising cork plank and stoppers according to the following variables: Visual quality, porosity, physical properties, mechanical properties and geographical origin.

The study was carried out on cork planks and natural cork stoppers from the most representative cork-producing areas in the world. Two training sets of international and national cork planks, comprised by 479 samples from Morocco, Portugal, and Spain and 179 samples from the Spanish regions of Andalusia, Catalonia, and Extremadura, were studied. A training set of 90 cork stoppers from Andalusia and Catalonia was also studied.

Original spectroscopic data were obtained for the transverse sections of the cork planks and for the body and top of the cork stoppers by means of a Foss-NIRSystems 6500 SY II spectrophotometer using a fiber optic probe. Remote reflectance was employed in the wavelength range of 400 to 2500 nm. After analyzing the spectroscopic data, quantitative equations and discriminant models were obtained with 70% of the samples. The best ones were then validated using 30% of the remaining samples.

The quantitative calibrations obtained using NIRS technology for porosity, visual quality and physical and mechanical properties are promising considering the heterogeneity and variability of a natural product such as cork. The qualitative analysis regarding geographical origin achieved very satisfactory results. At least 98% of the international cork plank samples, 95% of the national cork plank samples and 90% of the stoppers were correctly classified in the calibration and validation stage.

The results demonstrate the potential of VIS + NIRS technology as a rapid and accurate method for predicting the geographical origin of cork plank and stoppers. Applying these methods in industry will permit quality control procedures to be automated, as well as establishing correlations between the different classifications systems currently used in the sector. These methods will provide a certainly more objective tool for assessing the economic value of the product.

Keywords: Quercus suber L., NIRS, Cork plank, Stoppers

Type of submission: Poster
Theme: Topic 15. Cork
Name of presenter: Cristina Prades

PP060

Detection of tension wood that causes non-recoverable collapse in *Eucalyptus globulus* using near infrared spectroscopy

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Eucalyptus globulus is widely planted worldwide, but utilization of this species for sawn and engineered wood products remains limited by the occurrence of tension wood affecting sawing and drying performance. In particular, tension wood can cause non-recoverable collapse when timber is dried, leading to increased processing costs and reduced product value.

Near-infrared reflectance spectroscopy (NIRS) scanning technology provides a fast and cost-effective way of assessing several commercially important wood properties, including cellulose content, density and microfibril angle (MFA). Each of these properties is typically altered in tension wood, and their measurement should allow the presence and extent of tension wood to be assessed. An ability to detect tension wood in standing trees by non-destructive methods (such as NIRS scanning of small wood-core samples) would be a valuable tool for assessing the suitability of plantation-grown E. globulus for solid wood products.

This research investigated the use of NIRS to detect tension wood associated with non-recoverable collapse in Eucalyptus globulus by determining the limits of cellulose content, wood density and MFA that in combination were associated with the occurrence of non-recoverable collapse.

NIRS spectra were taken from 175 wood cores from a 20 year old plantation, green and after drying to 12% EMC. Shrinkage measurements were obtained before and after reconditioning. An additional 20 core samples were analysed by SilviScan-3 to determine MFA and density variation. Spectra from these strips were used to build NIRS calibrations based on SilviScan data. Calibrations were used to predict cellulose, density and MFA with the spectra from the larger set, and the results were related to the shrinkage and collapse data. Wood properties predicted by NIRS were clearly associated with shrinkage, showing high cellulose, high density and low MFA at the points of measured non-recoverable collapse. These findings form a basis for a rapid screening method for the non destructive assessment of non-recoverable collapse associated with tension wood using intact increment core samples.

Keywords: eucalyptus; tension wood; near infrared spectroscopy; plantation; collapse

PP061

Influence of the slope of terrain on the spatial variability of the wood density within *Eucalyptus* trees

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The aim of this study was to understand how contrasting environments influence the wood formation in Eucalyptus clones and the effect on wood density and spatial variability. Wood density was assessed in clonal tests represented by 150 Eucalyptus urophylla x grandis hybrids with 6-year-old growing under different conditions. The main difference among the sites was the slope of the terrain: the clonal tests were replicated at plan site (0° of inclination), at site with 20°, and 40° of inclination.

In order to provide experimental data to perform this study, gravimetric (reference) method and near infrared (NIR) spectroscopy were combined for assessing the wood density in a large sampling of Eucalyptus wood. Hence, regression model based on NIR spec-

tra was developed for estimating such wood traits from NIR spectra recorded at different radial and longitudinal positions along the height of the tree.

This approach allows the examination of the patterns of spatial variation of wood density within Eucalyptus trees. Variations in wood density along the stem are less consistent than those in the radial direction, especially close the base of the tree. Overall, the wood density strongly varied from pith (460 kg m-3) to bark (600 kg m-3) at the base. The radial variation in wood density at the base was about 140 kg m-3 while the radial variation at 25% of stem height was slightly low (~130 kg m-3). At 50% of height the trait also increased radially (~104 kg m-3), but in relative low magnitude. The density slightly increased from pith to bark at 75% of height (~50 kg m-3) and at the top of the tree the variation was of lower magnitude (~20 kg m-3). The radial variation at the base take into account the wood formed from the first to the sixty year of growth while the variation in the top of the tree refers to the wood developed with few months of difference.

The pith to bark variations in wood density were higher in the trees from the site presenting 40° of inclination. At 25% of the tree height, the radial variation was 104 kg m-3 in the site plan (0°), 133 kg m-3 in the site presenting inclination of 20°, and 157 kg m-3 in the site with 40° of inclination. In conclusion, the higher the inclination of the terrain, the greater the magnitude of wood density variation. Sloped terrains induce formation of reaction wood influencing the radial variation in wood traits.

Keywords: Hardwood; plantation; adaptation; specific gravity

PP062

Investigation on strength grading of drift wood in Taiwan by using stress-wave-based tomography

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In 2009, typhoon Morakot carried out more than 1.5 million ton drift wood and caused a serious problem of dealing with these drift wood in Taiwan. Although most of these drift wood are low-economic, there are still have large diameter and fine quality logs which can used for many applications, such as furniture, flooring, outdoor decking, etc. Therefore, the first thing to utilize these drift wood is to confirm and classify their wood qualities. After classifying, it not only can save the processing time and cost, these wood materials also can be used in construction and building materials. In recent years, the non-destructive testing (NDT) and non-destructive evaluation (NDE) method were widely used to inspect the properties of wood and wood-based composites. Among these techniques, ultrasonic and stress-wave based imaging techniques are the easer, lower cost and more efficient for wood. The purpose of this study was to evaluate wood holes/defects using a stress-wave tomographic technique.

There are two experiments to evaluate wood quality by using stress-wave technique in this study. Firstly, 300 mm in diameter and 100 mm thick cross-sectional camphor wood (Cinnamomum camphora) disc was prepared to chisel circular hole from 10 mm to 230 mm in central side and captured by stress-wave tomography. Then feasibility of using this tomography to evaluate wood quality is confirmed. Secondly, twenty drift wood logs over 400 mm in diameter were selected. After visual grading, longitudinal velocity test and stress-wave tomography, disks were cut and soaked in water over fiber saturation point (FSP) for tomography and surface hardness test, then small clear specimens (20 × 20 × 60 mm3) were cut and conditioned in 20oC, RH 65% four weeks for density and compression test. In order to evaluate the shapes and sizes of wood defects, two-dimensional image tomographic software (Arbosonic software) developed by Fakopp (Hungary) was used.

Result indicated that the stress-wave velocity decreased with increased the hole area. In addition, the relative velocity decreased with hole area in highly correlation, the R2 value of path D was 0.99. The difference in colour tomogram between hole area and surrounding area was observed when over 3% hole area. On the other hand, the longitudinal velocity of drift wood logs ranged from 1217-3399 m/s, the average velocity value was 2257 m/s. Results also revealed that combined the longitudinal velocity and tomography technique can provide a method to detect the decay of logs effectively.

Moreover, there were well relationships between strength with scale velocity, the correlation coefficients (r) was 0.92 for hardness and 0.80 for compression value, respectively. Based on the results of these experiment, we indicated that the stress-wave-based tomography technique provide incipient information of wood quality. Furthermore, it could be used for standing tree risk assessment or wood structure defect evaluation.

Keywords: Drift wood; Nondestructive techniques; Stress-wave-based tomography

PP063

Determining Modulus of Elasticity of Modified Poplar Wood Using Estatic and Ultrasonic Methods

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Poplar is a fast grown tree which has recently been demanded for wood industries. The fast grown species has low density and strength. Therefore, they are not suitable for applications with high mechanical strengths. This research has been aimed to improve poplar wood strength by a Combined-Hydro-Thermo-Mechanical Modification (CHTM) technique.

Wood blocks were cut in sizes of 50×55×500 mm and treated with water at temperatures of 120, 150 and 180 °C in a stainless steel cylinder for 0, 30 and 90 minutes as holding time and then at a press temperature of 180 °C. The blocks oven dried and then their Static and ultrasonic modulus of elasticity were determined and correlatios have been developed between them.

Results revealed that the modified wood attained a higher MOE, but did not give good correlation between Ultrasonic and static bending MOE.

Keywords: Combined Hydro-Thermo- Mechanical treatment, Static modulus of elasticity, Dynamic modulus of elasticity, Nondestructive evaluation.

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Influence of the slope of terrain on the spatial variability in wood density within *Eucalyptus* trees

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Introduction

✓ From an evolutive point of view, the variation of wood traits is vital for tree survival.

✓ Trees change their wood in order to respond to specific needs. For instance, if prevailing winds occur, the tree produces a different wood to resist to the bending forces induced by winds.

✓ Knowing how the key traits vary longitudinally and radially within the stem is of key importance for processors.

✓ Information about how the wood traits change within the stem in Eucalyptus clones planted on contrasting sites are unknown and would be useful in order to increase its economic value.

✓ The aim of this study was to understand how contrasting environments influence the wood formation in *Eucalyptus* clones and the effect on wood density and spatial variability.

Material and Methods

Vegetal material: Clonal test (6 years)

✓ Species: *Eucalyptus urophylla* x *E. grandis*

✓ Plantation density: 3 x 2 m (1667)

✓ Studied clones: 10

✓ Environments: 3 sites (inclination: 0°, 20° and 40°)

✓ Repetition: 5 individuals

✓ Total sampling: 150 trees (10 x 5 x 3): 750 discs

Wood characterization

✓ Gravimetric method for determining wood density

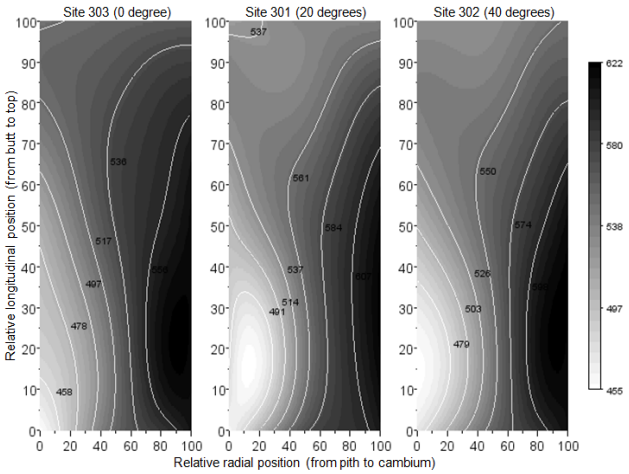
✓ NIR spectroscopy for phenotyping complete sampling

Site 303: **0** degree of inclination

Site 302: **40** degrees of inclination

Results and Discussion

Spatial variation of the basic density (kg m^{-3}) within trees and the effect of environmental factors on the variation patterns



✓ Variations in wood density along the stem are less consistent than those in the radial direction, especially close the base of the tree.

✓ Radial variation at the base was about 140 kg m^{-3} while the radial variation at 25% of stem height was slightly low (~130 kg m^{-3}).

✓ At 50% of height the trait also increased radially (~104 kg m^{-3}), but in relative low magnitude. The density slightly increased from pith to bark at 75% of height (~50 kg m^{-3}) and at the top of the tree the variation was of lower magnitude (~20 kg m^{-3}).

✓ The radial variation at the base take into account the wood formed from the first to the sixty year of growth while the variation in the top of the tree refers to the wood developed with few months of difference.

Concluding remarks

✓ The higher the inclination of the terrain, the greater the magnitude of wood density variation.

✓ Sloped terrains induce formation of reaction wood influencing the radial variation in wood traits.

Acknowledgment

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